

CITRUS REJUVENATION IN NE REGION OF INDIA

LAKSHMAN CHANDRA DE

ICAR-NRC for Orchids, Pakyong, Sikkim, India

ABSTRACT

In the world, citrus is dominated by sweet orange with a 64% contribution followed by mandarins with 20%, limes and lemons 10% and rest of the 6% contributed by grapefruit and other citrus fruits. In India, the area under citrus is 1.07 million ha with a production of 10.48 million tonnes and average productivity of 9.78 tonnes/ha. The traditional mandarin growing areas of North-eastern hill states experience humid subtropical climate with high rainfall in monsoon (summer) and low temperature during winter months. Other citrus groups s can be grown in the foot hills and valley of North –eastern states include sweet oranges, lemon, lime, pummel etc. Rootstocks used for budding of mandarin oranges are C. volckamariana, Tanyum (Citrus medica), Citrange, Trifoliate Orange, Kamla Australia, Kharna Khatta, C. latipes and C. jambhiri.

Heavy and long spells of rainfall, Soil erosion, Lack of desirable planting materials, Lack of application of amendments in acidic soils, Nutrient deficiencies, Rainfed cultivation, Lack of proper orchard management, No control of insect pests and diseases, Lack of marketing facilities, Problems of processing and Non-availability of trained manpower and extension support are major factor for citrus decline in the region. Strategies like proper Selection of site, Suitable method of planting, Supply of disease free elite planting material, Soil and nutrient management, Irrigation management, Proper orchard management, Management of insect-pests and diseases, Post -harvest management, processing and marketing and Extension services can be adopted for rejuvenation of old orchards. A suitable road map covering integrated approaches can be formulated for management of decline orchards.

KEYWORDS: Management of insect-pests, suitable road map & decline orchards

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INTRODUCTION

Globally citrus is cultivated in 114 countries. Among these, 53 countries grow citrus commercially with a total production of more than 115 million tonnes. On production point of view, China ranks first with 22.9 million tonnes followed by Brazil with 22.7 million tonnes and USA with 10.4 million tonnes. India with 10.48 million tonnes ranks 4th position. Mexico with 6.7 million tonnes and Spain with 6.5 million tonnes are rank at 5th and 6th position. Commercial Citrus fruits of the trade include sweet orange (*Citrus sinensis* Osbeck), Mandarin (*Citrus reticulata* Blanco), limes (*Citrus aurantifolia* Swingle), lemon (*Citrus limon* (L) Burm.f), grapefruit (*Citrus paradisi* Macf.) and pummel (*Citrus grandis* (L.) Osbeck). In the world, citrus is dominated by sweet orange with a 64% contribution followed by mandarins with 20%, limes and lemons 10% and rest of the 6% contributed by grapefruit and other citrus fruits. In India, the area under citrus is 1.07 million ha with a production of 10.48 million tonnes and average productivity of 9.78 tonnes/ha. Total mandarin production in India is 3.25 million tonnes with 0.32 million ha area and 10.16 tonnes/ha as productivity while limes/lemons have occupied an area of 0.21 million ha with 2.10 million tonnes production and 9.62 tonnes/ha productivity.

In India, both Maharashtra with 278,000 ha area under citrus in Central India and Andhra Pradesh with

1,28,000 ha in South India enjoy a distinct tropical climate where there is no well defined winter season with low temperature regime. The Kinnow mandarin is commercially successful in north Indian states like Punjab, Haryana and Rajasthan falling under subtropical climate with distinct winter season. Similarly, the traditional mandarin growing areas of North-eastern hill states experience humid subtropical climate with high rainfall in monsoon (summer) and low temperature during winter months.

It is of particular interest because of its high content of vitamin C and for preparation of refreshing juice, squash, cordials, pickles, essential oils and other by-products. Of the various types of citrus grown in India mandarin, sweet orange and lime/lemon are of commercial importance.

The NEH Region of India is one of the richest reservoir of genetic variability with 136 horticultural species growing in the region. The region has been described as one of major centre of diversity for citrus, banana and mango. This region is the natural home of *Citrus indica*, *C. assamensis*, *C. latipes*, *C. ichagensis*, *C. macroptera*, *C. aurantium*, *C. reticulata*, *C. megaloxycarpa*, *C. jambhiri*, *C. aurantifolia*, *C. grandis*, *C. limon* and *C. karna* (Ghosh, 1984).

Status

At present, the area under various citrus crops has increased from 71.8 thousand hectares (TH) in 2005-06 to 139.86 TH and the average production in region in the same period increased from 289.1 thousand tons (TT) to 737.08 TT. Mandarin is cultivated in all states of NEH Region with Meghalaya leading area. Citrus occupies first position on area basis covering about 115.4 thousand hectares Table 1).

Table 1: Crop Wise and Production of Fruit Crops in NEH Region (2010-11)

Crop	NEH States			India		
	Area (Ha)	Production (MT)	Productivity (MT/Ha)	Productivity (Mt/Ha)	Leading State	Productivity (MT/Ha)
Pineapple	59,276	706,877	11.93	15.95	Karnataka	62
Papaya	11,211	176,128	15.71	39.75	Tamil Nadu	164
Mango	11,133	74,611	6.70	6.61	Punjab	15.83
Litchi	8,930	58,845	6.59	6.41	Punjab	14.67
Guava	6,952	103,048	14.82	12.02	MP	28.99
Citrus	115,482	611,521	5.30	8.82	Karnataka	20.73
Banana	81,454	1,015,075	12.46	35.86	Tamil Nadu	65.83
Apple	13,566	28,433	2.10	10.00	J&K	13.07
Grapes	1755	20,500	11.68	11.08	Punjab	28.32
Kiwi	2670	4079	1.53	--	--	--
Passion fruits	9866	78,491	7.96	--	--	--
Others	22,084	72,720	3.29	--	--	--

Source: NHB, 2010-11.

According to Department and Agricultural Cooperation, ICAR, the area under various fruits crops was 7216312 hectares and production was 88977134 tones with average productivity of 12.3 t/ha during 2013-2014. Major citrus belts of NEH Region along with area, production and productivity is mentioned below (Singh and Naqvi, 2001) (Table 2).

Table 2: Citrus Belts of NEH Region

State	Cultivars	Major belts	Area (,000 ha)	Production (,000 tonnes)	Productivity (t/ha)
Arunachal Pradesh	Khasi mandarin	West Siang District, Lohit District	19.6	24.2	1.6

Table 2: Contd.,					
Assam	Assam lemon Acid lime Mandarin orange	Tinsukia, North Cachar Hills, Nowgaon, Jorhat, Barpeta, Dibrugarh, Kamrup, Lakhimpur, Sonitpur, Khetri	14.4	114.9	8.2
Manipur	Oranges, Manadarin, Lemons	Tamenglong, Tapaimukh and Jiribam, Ukhrul, Churachandpur, Senapati	2.2	9.0	4.1
Meghalaya	Mandarin	Southern and western slope of Khasi Hills, West Garo Hills, Central Jaintia Hills, Mawsynram and Cherrapunjee	7.3	32.9	4.5
Mizoram	Mandarin, Oranges, Lemons	Kolasib, Tawitaw, Aizawl, Thing dawal	8.8	33.5	3.9
Nagaland	Mandarin	Longnok, Mokochung, Tuensang, Wdokha, Khonsama	1.4	5.3	3.8
Sikkim	Mandarin	East district, South district	6.8	6.0	1.13
Tripura	Mandarin Assam lemon	Dharmanagar, Kumarghat, Jampui Hills, Amonpoi, Vhangmon	12.7	44.5	3.5

Genetic Resources/Biodiversity:

The North-Eastern region of India has been identified as one of the major centre of diversity of citrus having about 17 species, 52 varieties and seven natural hybrids (Bhattacharjee and Dutta, 1956). The 17 species and 7 hybrids are described below (Table 3)

Table 3: Indigenous Citrus Species of NEH Region

Sl. No.	Botanical Name	Common Name	Distribution	Uses
1.	<i>Citrus medica</i>	Citron	Garo hills of Meghalaya and Siang districts of Arunachal Pradesh	Table use, rootstock
2.	<i>C. lemon</i>	Assam lemon	Assam, Meghalaya	Table purpose, juice, cordial, rootstock
3.	<i>C. jambhiri</i>	Kata jumiri, Rough lemon	Assam	Citric acid extraction, Table purpose by tribals, rootstock
4.	<i>C. karna</i>	Soh Sarkar	-	Rootstock
5.	<i>C. aurantifolia</i>	Abhayapuri lime, Acid lime	Assam, Arunachal Pradesh, Sikkim	Table purpose, juice, pickle
6.	<i>C. limetta</i>	Mitha, Kagzi	Jaintia Hills (Meghalaya)	Table purpose
7.	<i>C. reticulata</i>	Mandarin	Meghalaya Arunachal Pradesh, Sikkim	Table purpose, juice, squash
8.	<i>C. nobilis</i>	King orange	Upper Assam	-
9.	<i>C. indica</i>	Indian wild orange	Assam, Meghalaya and Garo Hills of Meghalaya	Medicinal value

Table 3: Contd.,				
10.	<i>C. sinensis</i>	Sweet orange	Meghalaya, Arunachal Pradesh	Table purpose, juice, squash
11.	<i>C. aurantium</i>	Sour orange	Mokokchung of Nagaland, Khasi Hills of Meghalaya	Oil extraction, rootstock
12.	<i>C. maxima</i>	Pummelo	Assam, Meghalaya	Table purpose
13.	<i>C. megaloxycarpa</i>	Bor Tenga	Assam	-
14.	<i>C. ichangensis</i>	Ichang papeda	Barail range of Naga hills	Inedible, cold hardy
15.	<i>C. macroptera</i>	Satkara	Shella area of Meghalaya, Manipur, Mikir and North Cachar Hills of Assam, Mizoram and Jampui Hills of Tripura	Used by local tribals for medicinal purpose and in cooking
16.	<i>C. latipes</i>	Soh Shyrkhoit	Shillong, Mawflong, Pynurslee and Cherapunji of Meghalaya	Cold tolerant rootstock
17.	<i>C. assamensis</i>	Ada jamir	Karimganj, North Cachar of Assam, Shella and Cherapunji of Meghalaya	Consumed by local people.

The natural hybrids described by Bhattacharjee and Dutta (1956) are:

- Soh – Khyllah No.1
- Soh - Khyllah No.2
- Soh - Khyllah No.3
- Hash Khuli
- Sarbati
- Nicholsroy
- Dewa tenga

Growth and Production of Identified Citrus Species

Mandarin Orange (*Citrus Reticulata* Blanco)

Approximately, 1600 ha are under mandarin orange cultivation in nine states namely Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Tripura, Sikkim and the Darjeeling District of west Bengal. A subtropical to sub-temperate climate and evenly distributed rainfall about 2000-3000 mm throughout the years are required the state for successful cultivation of Mandarin. An average temperature of 10-25°C along with cool summer in the region, favours quality fruit production for supply from November to February. Performance of some improved varieties of Mandarin Oranges is listed in Table 4.

Table 4: Yield and Physiochemical Characteristic of different Varieties of Mandarin Oranges Over 15 Years

Varieties	Yield/Tree (No. of Fruits)	Fruit wt (G)	Fruit size (cm x cm)	Juice/fruit (ml)	Peel thickness (mm)	TSS (%)	Acidity (%)	Ascorbic Acid (mg/100 ml Juice)
Mediterranean Orange	331	186	6.38 x 6.9	77	5.77	10.0	1.48	30.7
King Theppi	380	145	60 x 6.3	75	5.3	9.2	1.39	30.0
Nagpur Santra	227	144	5.9 x 6.5	63	4.2	9.4	0.8	28.20
Hill Mandarin	164	98	5.6 x 6.2	49.5	3.8	9.5	1.07	25.0

Table 4: Contd.,								
Sikkim Orange	168	95.4	5.8 x 6.3	57.2	3.87	10.0	1.06	23.3
Wilking Orange	144	58.6	4.3 x 5.6	24.3	2.00	9.9	1.11	26.4
Khasi Mandarin	282	133	6.25 x 6.56	65.5	3.65	10.1	1.01	26.1
Citrus Zigardio	76	134	6.2 x 6.98	62.9	8.06	7.7	1.16	24.63

Amongst Mandarin groups, Khasi mandarin, Sikkim mandarin and Darjeeling mandarin are cultivated at large scale in the region although King Theppi, Nagpur Santra have great potential at low altitude in the subtropical climate; *Citrus zigardio* is a late ripening Mandarin species which can be exploited for harvesting fruits during March - April.

Sweet Oranges (*Citrus Sinensis* Osbeck)

Such type of thick skinned oranges can be grown in the foot hills and valley of North –eastern states. Sweet Oranges are good for distance transportation. Among 14 varieties of Sweet oranges tested, Soh-niang riang has been found highest yielder of fruits (450 Nos.) followed by Valencia Newton (353.3), Exelcier Malta (329), Daccus Malta (273), Malta Orange (266) and Rubi Blood Red (246.6)(Table 5).

Table 5: Yield and Physicochemical Characteristics of Sweet Oranges Over 15 Years

Varieties	Yield/Tree No. of Fruits	Fruit wt(g)	Fruit size (cm x cm)	Juice/fruit (ml)	Peel thickness (mm)	TSS (°B)	Acidity (%)
Washington Malta	86.7	223	6.31 x 7.6	73.2	6.7	7.7	2.4
Vanilla Malta	156.8	201	7.5 x 8.1	96.5	6.4	8.4	2.31
Valencia Newton	353.3	163.5	5.8 x 6.1	52.9	72	8.5	1.73
Rubi Malta	211.2	103.0	5.6 x 6.4	38.0	8.0	8.2	1.83
Excelier Malta	329	177	5.7 x 6.2	67.20	5.4	8.4	3.03
Malta orange	266	180	6.4 x 6.7	95.20	5.2	8.1	1.93
Rubi blood Red	246.6	148.5	5.6 x 6.5	71.0	5.2	8.4	2.34
Whittawa Malta	181	158	5.6 x 6.5	64.0	6.8	7.5	1.51
Majurica Malta	151	192	6.6 x 8.1	47.7	9.6	7.3	1.46
Italian Large	247	172	5.8 x 6.6	85.1	7.4	8.3	1.83
Daccus Malta	273	179	6.0 x 6.6	84.4	8.6	8.2	2.3
Mousambi Australia	233	170	5.9 x 6.8	82.6	8.4	8.3	1.6
Para Malta	196	125	5.8 x 6.5	82.6	6.2	9.0	2.5
Soh-niang riang	450	120	5.7 x 7.0	28.0	6.2	-	-

Individual fruit weight was found highest in Washington Malta (223 g) followed by Vanila Malta (201 g) and Majurica Malta (192 g). TSS: Acidity ratio was highest with Mousambi Australia (5.18) followed by Majurica Malta (5.0), Whittawar Malta (4.96) and Valencia Newton (4.91).

Acid Lime (*Citrus Aurantifolia* Swingle)

Limes are thinned and become yellow after ripening. The pulp is sour, greenish white in colour and useful for making curries and pickles. Acid limes can be grown successfully at low hills (1000 m m.s.l.) of region with special care against bacterial canker and powdery mildew diseases. A chance seedling of Acid Lime collected from Pangin area of East Siang District of Arunachal Pradesh has been found promising for low to mid altitude of Arunachal Pradesh. The characteristics of above mentioned selection is described below:-

Parameters	Values
Plant height	3.7 m

Canopy spread	342 cm x 352 cm
Period of flowering	January to September
Period of fruiting	March to November
Fruit yield/plant	800
Fruit weight	50 - 69 g
Juice content/fru	25 - 32 ml
Rind thickness	2.4 - 3.0 mm
Acidity	7.5%

Assam Lemon (*Citrus limon*, Burm)

It is a popular variety of lemon and is resistant to vagaries of climate and it can be grown commercially in subtropical humid climate of NE states. The fruits of variety are oblong, medium large in size, highly juicy and can be used commercially for preparation of juice, cordial *etc.*

The physiochemical characteristics of fruits of Assam Lemon, grown in mid hills of NE region are given below:

Parameters	Values
Fruit weight	120 g
Fruit size	9.5 cm x 5.8 cm
Peel weight	50 g
Juice content/fruit	39 ml
T.S.S.	6.5 °Brix
Acidity	5.6%

Period of fruiting June to November

Kinnow:

Kinnow is a hybrid between King Orange and willow leaf Mandarin and can be grown at low to mid hills of NE region. Fruits are bright orange in colour, oval, glossy and slightly tight skinned. Kinnow is dwarf in stature and can be used in high density planting. Physiochemical parameters of fruits of Kinnow grown at low hills of region are described below:

Parameters	Value
Average fruit weight	130g
Average fruit size	6.5 cm x 5.4 c
Average No. of juice vesicles	11.0
Average No. of seed/fruit	16

Juice content/fruit	58 ml
T.S.S.	8.3 °Brix
Acidity	2.04%
Period of fruiting	November to March

Citrus Species used for Rootstocks

There are altogether 10 rootstocks used for budding of Mandarin Oranges. Amongst them, *Citrus volckamariana* had highest trunk girth (81.3 cm) followed by *Citrus latipes*. However, highest plant height was recorded in *Citrus latipes* (5.78m) followed Rough Lemon (5.65m), Citrange (5.27m). The number of fruits per tree varied from 36 Nos. in *Citrus taiwanica* to 567 in Cleopatra Mandarin. Fruit characteristics of different rootstocks are listed in Table 6.

Table 6: Physicochemical Characteristics of Fruits of different Rootstocks

Name	Fruit length (cm)	Fruit Diam (cm)	Fruit Wt (g)	Pulp Wt (g)	No. of Seeds	Juice/ fruit (ml)	TSS (°B)	Acidity (%)
<i>C. volckamariana</i>	7.0	6.5	140	85	2.8	25	7.6	4.9
<i>C. jambhiri</i>	6.5	6.4	125	62	3.0	13	7.8	3.96
Citrange	5.8	6.0	96	66	2.0	18.6	10.8	5.74
Trifoliate Orange	4.4	4.2	40	26.4	17.6	6.67	12	5.28
Kamla Australia	9.4	8.9	352	72.7	2.5	57	6.7	5.12
Kharna Khatta	9.6	8.7	309	131.5	3.0	37.7	4.77	5.24
<i>C. latipes</i>	7.9	8.4	285	130.5	4.2	50	7.4	3.45
Tanyum	9.03	6.63	173.3	92.4	29.5	16.9	6.7	5.6

Out of 8 rootstocks evaluated in subtropical hill zones, Kamla Australia had highest fruit weight (352 g) followed by Kharna Khatta (309 g) and *Citrus latipes* (285 g) (Table 6). T.S.S. was maximum in Trifoliate Orange (12°B), Tanyum (*Citrus medica*), a local rootstock produced maximum number of seeds/fruits (29.6) followed by Trifoliate Orange (17.6). Kamla Australia yielded highest amount of juice/fruit (57 ml) followed *C. latipes* (50 ml) and Kharna Khatta (37.7).

PRODUCTION TECHNOLOGY

Selection of Planting Materials

To obtain well developed vigorous stocks, it essential that due care should be given to the quality vigour of plant. Healthy, fairly old, true to the type heavy bearing trees with standard quality of fruits should only be selected as mother tree for propagation. Tree should also be free from pests, mycoplasmas and virus diseases.

Propagation

Citrus is mainly propagated through seeds, air layering and uprooted planted propagates. Although citrus may be propagated by cutting, grafting or budding, various species are propagated by different methods.

Propagation through Seeds

Seed should be collected from vigorously growing and healthy trees and from well developed mature fruits, all seeds poorly developed immature fruits should be discarded. In general large seeds show higher and quicker germination and better growth than the small ones. Seed collected from immature grape fruits did not germinate. Seeds should be immediately sown in the nursery after harvesting for better germination.

Vegetative Propagation

Cutting

Many species of citrus viz. Assam lemon, lime *etc.* can be successfully raised from cutting and it is very useful method of propagation, especially when a species is desired to be clonally propagated on its own root systems. Moreover, clonal propagation of rootstocks is possible by the use of cutting. Cutting should be taken 10-25 cm long and 2.5 cm thick from middle portion of one year old shoots. Best result is obtained when cuttings are collected during the cooler part of the day, preferable in the morning. It is the common practice to give the top cut 1 cm above a node and the basal cut is given slightly below anode. For good results cutting should be treated with 500 ppm IBA. July is the best time for planting of cutting.

Air Layering

Air layering is fairly common in India, Acid lime, kinnow and sweet lime are commonly propagated by means of air layering. Generally, long, one to two year old shoots are used for air layering, first the leaves are removed from the based of the selected shoots, then the stem is given a notch or is girdled by removing a ring of bark about 2-3 cm wide.

Budding

Budding is the most widely adopted practice for raising planting materials through vegetative propagations. In mandarin orange, rough lemon, Cleopatra mandarin, *Citrus volckemariana*, *C. latipes*, *Citrus taiwanica*, trifoliate orange, carrizo Citrange, Troyer Citrange Tanyum (Local) have been found to be promising rootstocks for mandarin orange. Some of these rootstocks are resistant/tolerant to root rot and viral, mycoplasma diseases. Rangpur lime, rough lemon and Cleopatra mandarin are suitable for deep soils whereas, trifoliate orange, troyer and carrizo citrange are recommended for medium to shallow soils. Nursery can be raised with the seed extracted from the healthy rootstock. It takes about 12-15 months to attain pencil thickness which is the proper stage of budding. Budding can be done in the month of March and August to September when apical tissue is in active growth stage. T-budding is the most common and popular method for propagation of citrus.

Performance of Budded Mandarin Oranges

Among different combination with four types of mandarin oranges (Khasi Mandarin, Nagpur Santra, Hill Mandarin and Sikkim Orange) and six species of rootstock. (Tanyum, *C. volckamariana*, *C. latipes*, Trifoliate Orange, Rough lemon and Karna Khatta), *Citrus latipes* + Hill mandarin attained maximum plant height (2.5m), stock diameter (5.8cm) and no. of branches (15 cm) (Table 7) (De at al, 2006).

Table 7: Growth Performance of Budded Mandarin Plants (After 3 Years)

Treatments	Plant Height (m)	No. of branches/ Plant	Canopy spread (cm)	Stem Diameter (cm)		No. of Fruits
				Stock	Scion	
Tanyum + Khasi mandarin	1.98	10	144 x 145	5.2	4.3	19
<i>C. Volckamariana</i> + Khasi mandarin	2.25	8.5	140 x 160	4.95	4.1	12
Tanyum + Sikkim Orange	2	10	130 x 160	4.5	4.0	50
Tanyum + Nagpur Santra	2.25	8	145 x 140	5.2	4.8	55

Table 7: Contd.,						
Tanyum + Hill mandarin	2.0	10	170 x 140	4.8	3.6	26
Nagpur Santra + <i>Volckamariana</i>	2.3	15	130 x 148	6	5.5	2
Sikkim Orange + Rough lemon	2.0	8	110 x 130	5.0	4.5	7
<i>C. latipes</i> + Hill mandarin	2.5	15	140 x 170	5.8	5.3	25

Table 8: Physicochemical Characteristics of Budded Mandarin Oranges

Treatment	Fruit wt (G)	Fruit Diameter (CM)	Pulp wt (G)	Juice Content (ML)	T.S.S (B)	Acidity (%)
Tanyum + Khasi mandarin	102.7	6.3	82.7	45.0	10.0	1.63
<i>C. Volckamariana</i> + Khasi mandarin	97.5	5.6	63.5	47.0	8.2	1.45
Tanyum + Sikkim Orange	121.5	6.6	85.1	58.5	8.8	1.23
Tanyum + Nagpur Santra	135.0	6.8	8.3	67.0	8.8	1.58
Tanyum + Hill mandarin	131.3	6.6	99.5	53.9	8.6	1.52
Rough lemon + Sikkim orange	88.0	5.5	62.4	35.0	7.6	1.19
<i>C. latipes</i> + Hill mandarin	116.0	6.5	78.14	41.8	9.4	1.20

Out of different rootstock - scion combinations, Tanyum + Nagpur santra produced highest number of fruits (55) in 4th year of planting followed by Tanyum + Sikkim orange and Tanyum + Hill Mandarin (Table 7). Quality parameters of fruits among different combinations are given in Table 8.

Selection of Site

The orange cultivation can be done in plains as well as hill slopes having good drainage and fertile soil. The soil depth of 1m is necessary. In order to get sufficient sunlight in hill planting should preferably be done in southward directions.

Layout and System of Planting

Orchards can be established in square systems by keeping row to row and plant to plant distance of 6 x 6m whereas on hills slopes, contour bunds can be made at a distance of 5.5 to 6.0 m depending upon the gradient and then half-moon terraces can be made between the two contour bunds at a distance of 6m. On the outside of the half-moon terrace, make bund with an outlet on onside for draining excess water. In the middle portion pit of 1m x 1m size should be made in advance. Fill the pits with top soil mixed with rotten FYM @ 12-15 kg/pit and raise the level of pit to a height of 15-20 cm from ground level. Allow it to settle for a minimum period of one month.

Time and Method of Planting

Planting is mostly done on hill slopes under rainfed conditions and spring or rainy season planting is preferred. Uprooting and planting of the saplings should be done during cloudy or rainy days. Spread the root properly while planting and press the soil firmly around stem. Stacks should be provided for budded plants to protect bud union from breakage. Keep the bud union above ground level.

CULTURAL ASPECTS

Fertilization and Manuring

Citrus, is a nutrient loving plants and 15 elements have been known to be essential for proper growth of mandarin orange. It is advisable to apply the fertilizers in 2-3 split doses and one third of the total nutrient requirement may be applied in organic form and other two third in inorganic form. For non bearing orchard, fertilizer application may be done in an area more than drip circle, leaving 15-30 cm radius around the tree trunk while for bearing trees, it may be applied by broadcasting from trunk to outer periphery of the plant canopy, leaving about 30 cm radius around the tree trunk. It should be properly mixed in the soil by giving light hoeing. The detail of manure schedule is given in Table 9. It has been reported that the foliar spray of zinc (0.4%) with copper (0.2%) + iron (0.1%) increased the growth of new foliage (March flush). The cumulative fruit drop was also recorded minimum with the combination of zinc, copper and magnesium. The application of zinc alone gave more yield than other single nutrient foliar application on trees.

Table 9: Schedule of Manuring and Fertilizer Application

Type of Manure	Time of Application	Age of the plant					
		I Year	II Year	III Year	IV Year	V Year	VII Year Onwards
FYM	February	0	5 kg	10 kg	15 kg	20kg	25-40 kg
Urea	March-April	100g	150g	200g	250kg	300g	350 g
SSP		100g	200g	300g	400g	500g	600 g
MOP		50g	100g	150g	200g	250g	300g
Slacked lime (once in 2-3 years)	February	0	1 kg	-	3kg	-	5 kg
Urea	June	100g	150g	200g	250g	300g	350g
SSP	Sept-October	100g	200g	300g	400g	500g	600 g
MOP		50g	100g	150g	200g	250g	300 g
Urea		100g	150g	200g	250g	300g	350 g
SSP		100g	300g	300g	400g	500g	600 g
MOP		50g	150g	150g	200g	250g	300 g

Training and Pruning

The trees are trained to a single stem up to a height of 40-50 cm from the ground level and there after allow 4-6 well shaped branches to grow. Prune water sprouts, root stock suckers and dried branches. Cut ends which are more than pencil thickness should be pasted with Bordeaux paste.

Intercropping

In order to improve the fertility and physical condition of orchard soil, leguminous crops like pea, cowpea, jack bean, rice bean, french bean, green gram, black gram, stylosanthes (as fodder) dwarf, shallow rooted, less exhaustive seasonal vegetables, pineapple and papaya can be grown as intercrops. On hill slopes two rows of pineapple can be planted just below the contour bunds at a spacing of 60 cm from and 30 cm from plant to plant.

High Density Planting

High Density Planting (HDP) of khasi mandarin can be laid out with five different spacing of 2 x 2 m, 2.5 x 2 m, 3 x 3 m, 4 x 4 m and 5 x 5 m. Quality parameters of Khasi mandarin fruits under different spacing are enlisted in Table 10.

Table 10: Fruit Quality of Khasi Mandarin under HDP

Treatment	Fruit wt (g)	Fruit Size (cm x cm)	Pulp wt (g)	Juice Content	T.S.S	Acidity
2m x 2m	94.7	6.0 x 4.5	71.7	46.2	9.8	1.7
2.5m x 2.5m	86.6	5.5 x 4.6	62.0	44.6	8.6	1.6
3m x 3m	96.0	6.2 x 4.1	72.8	58.12	8.6	1.6

Rejuvenation of Declined Orchard

A twenty years old orchard of Khasi mandarin and another one of acid lime cv. ARL-1 have been identified and two trials laid out separately on rejuvenation (Top working) with the following schedules.

1. Khasi Mandarin Top Working Heights

0.5 m

1.0m

1.5m

Primary Branch Control

2. Acid Lime Top Working Heights

0.5m

1.0m

1.5m

Primary Branch Control

Table 11: Rejuvenation of Khasi Mandarin

Treatments	Plant Height (m)	No. of Branches	Canopy Spread (cm)	Shoot Circumference (mm)	Shoot Length (m)	No. of Fruits
Primary branches pruned	5.0	8	280 x 270	76	4.76	220
1.5m	4.2	7	220 x 240	79	3.9	100
1.0m	3.8	6	174 x 195	74	3.6	65
0.5m	3.30	6	155 x 140	85	3.07	15
Control (without pruning)	6.0	12	430 x 450	85	6.0	190

Table 12: Physicochemical Characteristics of Dehorned Khasi Mandarin Fruits

Treatment	Fruit Size (cm x cm)	Fruit wt (g)	Pulp wt (g)	Juice Content (ml)	T.S.S (°B)	Acidity (%)
Primary Branch pruned	6.5 x 5.2	123.6	95.5	56.64	10.0	1.3
1.5 m	6.0 x 5.0	113.2	91.4	51.8	10.4	1.4
1.0 m	5.5 x 4.8	72.5	76.0	50.2	9.8	1.0
0.5 m	5.5 x 4.6	81.20	61.0	49.1	9.6	0.62
Control	5.5 x 4.5	79.3	58.3	42.4	9.6	1.08

Out of four treatments (pruned), primary branch pruned produced maximum number of fruits (220) followed by pruning at 1.5m height (Table 11). In terms of quality, fruits from pruned trees were better than control (unpruned)

(Table 12). Pruned plants produced fruits with higher quality viz., larger fruit size, weight, more pulp weight, juice content, lower acidity over control but primary branch pruned treatment gives higher TSS than unpruned control and others.

Rejuvenation in Acid Lime

The trees were pruned or dehorned at four different heights of the main trunk of a plant i.e. 0.50 m (T₁), 1.00 m (T₂), 1.50 m (T₃) and all primary branched pruned (T₄) including control (TO) without pruning. After two years of pruning, data on vegetative growth parameters viz. number and length of new shoots, plant height, shoot diameter, trunk diameter, canopy spread and reproductive parameters viz. Number of fruits/plant, fruit size, fruit weight, peel weight, pulp weight, T.S.S. and acidity were recorded.

Out of five treatments, after second year of pruning, primary branch pruned trees produced maximum number of fruits/plant (237.6) with maximum fruit weight (70.83) and pulp weight (50.56) followed by pruning at 1.50 m and 1.0 m (Table 13).

Table 13: Effect of Pruning on Reproductive Growth of Old Declined Orchard of ACID Lime cv. 'ARL-1'

Treatment	No. of Fruits	Juice Content /Fruit (ml)	Fruit Size (cm x cm)	Fruit wt (g)	Peel wt (G)	Pulp wt (G)	T.S.S.	Acidity
T ₁ (0.50m)	49.6	20.00	5.38 x 5.12	66.50	20.18	46.32	7.0	5.5
T ₂ (1.0m)	160.0	20.00	4.50 x 4.42	54.50	14.25	40.25	6.75	5.08
T ₃ (1.5m)	185.3	21.25	5.18 x 4.72	58.00	20.20	37.8	7.17	5.56
T ₄ (Primary branch pruned)	237.6	27.50	5.27 x 5.03	70.83	20.27	50.56	7.45	5.82
Control (unpruned)	90.3	23.75	5.14 x 4.73	58.30	19.95	38.35	7.7	5.79

Major Constraints

Heavy and Long Spells of Rainfall: It causes damage during flowering and fruit setting. It favours development of mosses, lichens and fungal pathogens.

Soil Erosion: In hills planting of trees in steep slopes (60-70%), causes heavy soil erosion by surface run off due to heavy rain. It causes loss of plant nutrients and exposure of the roots.

Lack of Desirable Planting Materials: All the old mandarin orange plantations are of seedling origin and budded plants on desirable rootstocks are never planted on hill slopes or in the valleys. The disease free, true to type, genuine planting materials is lacking in the region. Acclimatization of tissue cultured plantlets is a slow and difficult process.

Lack of Application of Amendments in Acidic Soils: It has been reported that citrus trees perform well in soils having pH range of 5.5 to 6.5 and it causes deficiency of boron, zinc and iron. Farmers do not use any type of amendments for such type of soils.

Nutrient Deficiencies: Planting of trees in steep slopes and heavy rainfall and lack of supplementary application of nutrients cause gradual decrease in soil fertility. Deficiency of phosphorous, zinc, magnesium, boron, molybdenum, calcium *etc.* cause decline in production and dieback in this region. In Sikkim, nitrogen is the limiting factor in citrus orchards.

Rainfed Cultivation: In NEH Region, where irrigation facilities do not exist, severe shortage of soil moisture on the hill slopes during winter season and pre-monsoon time causes dieback of young plants.

Lack of Proper orchard Management: The general neglect, mixed planting, undesirable intercropping, improper spacing, vigorous, weed growth and inadequate nutrition cause poor yield of trees.

No Control of Insect Pests and Diseases: Among insect pests, trunk borers, scales, aphids and leaf miners are mainly responsible for decline in citrus plantation of NEH region. Trees suffer greatly due to attack of fungal diseases like cracked bark, root rot and gummosis for which no proper fungicidal programme is adopted.

Citrus greening causing chlorosis, thickening of leaf blade, off season blooming, leaf shedding and dieback is prevalent in the region. It generally spread through infected budwood and citrus psylla. Tristeza, a viral disease causes leaf falling root decay, twig diebacks and sudden death of the trees is common occurrence in the region. Other causal factors associated with citrus decline are dieback, sooty mould, scab, powdery mildew, felt and canker.

Lack of Marketing Facilities: There is no network of organized market in the region and the farmers used to get low return by selling the perishable produce at throw way prices to middlemen. Transportation of perishable products is another serious constraints in the region.

Non-Availability of Trained Manpower and Extension Support: Lack of trained manpower and extension services are lagging far behind which causes awareness of production aspects in the region.

Problems of Processing: The processing industry only can help in proper disposal of perishable commodities which needs close linkage with market and transport facilities. Till today, there are hardly and cold storage facilities available, few processing units exist but not are functioning upto the desired capacity.

Financial Constrains: The high capital cost involvement for establishment of orchard and infrastructure, less expenditure on research work and lack of insurance facilities in the citrus are the common financial constrains.

Strategies

- **Proper Selection of Site**

For establishment of new orchards, sites should be selected at an altitude of 50m – 1500m with annual rainfall ranging from 750mm – 2500mm. Manual cleaning or spraying with Cu-based fungicide is required time to time to control the growth of mosses, lichens *etc.*

- **Suitable Method of Planting**

In undulating topography of this region, having more than 25-30% slopes, planting should be done along contour grades on half terraces or bench terraces to check soil erosion and losses of nutrients.

- **Supply of Disease Free Elite Planting Material**

Strict quarantine and bud wood certification programme should be started for production of disease free planting materials. The shoot tip grafting as standardized by NRCC should be exploited at commercial scale to eliminate virus like diseases from elite germplasm of citrus.

- **Soil and Nutrient Management**

Application of lime or heavy organic manuring is advised in regular basis to maintain soil pH near to neutral. A dose of 600 g N, 200g P₂O₅ and 200g K₂O has been found optimal in bearing orchard of Khasi mandarin to produce 1070 fruits/tree (De. *et al*, 2004). A combined application of 0.1% FeSO₄, 0.4% ZnSO₄ and 0.2% CuSO₄ as foliar spray is found effective to yield 880 fruits/tree in Khasi mandarin.

- **Irrigation Management**

Water stress problem can be overcome by using of microjet irrigation followed by drip irrigation can be followed winter season.

- **Proper Orchard Management:**

The orchards should be cleaned and opened by removing other forest trees including bamboo bushes, wild banana, plant parasites and weeds. Dead and infected branches should be pruned and applied with Bordeaux paste. The base of trees should be made flat and weed free to facilitate fertilizer application. The tree trunks should be painted by Bordeaux paste upto 1 metre from base. Weeds should be removed from the entire orchard during July-August manually or by the application of glyphosate @ 4 litres/Ha. Mulching should be done with locally available dry leaves/straw/grasses near the base of trunks to conserve soil moisture during lean period.

- **Management of Insect-Pests and Diseases**

- **Insects - Pests**

- **Control Measures**

- | | |
|-----------------|--|
| • Citrus psylla | Spraying with Malathion (0.05%) or Monocrotophos (0.025%) |
| • Leaf miner | Spraying of phosphomidon (1 ml/l) or monocrotophos (1.5ml/l). |
| • Scale insects | Spraying of Malathion (0.1%) |
| • Trunk borer | Injecting petrol or nuvan into the holes and by plugging the holes with mud. |
| | Spraying with monocrotophos (0.05%) |

- **Diseases**

- **Control Measures**

- | | |
|------------------|---|
| • Tristeza | Control of aphids and use of cross protected seedlings. |
| • Citrus canker | Cutting of infected twigs followed by spraying of 1% Bordeaux mixture. |
| • Gummosis | Scraping of the affected area and application of Bordeaux Mixture of copper oxifluoride. |
| • Powdery mildew | Pruning of dead twigs followed by application of tridemorph or benzimidazole (3 g/l). |
| • Greening | Control of insect vector use of certified planting materials and application of tetracycline (500 ppm). |

- **Post Harvest Management, Processing and Marketing**

There is a need of integrated approach for post harvest handling including standardization of harvesting maturity, commercial grade degreening, packaging techniques, storage techniques preservation methods, control of post harvest diseases transportation and quality control. There should be established processing units to formulate value addition products of excess produce. The Government organization viz APEDA, NHB, NCDC and NAFED may have to be involved for improving marketing and post-harvest handling infrastructure of citrus industry.

- **Extension Services**

The following strategies should be taken up for quality production of citrus.

- Building of farmers management and problem solving capacity through field work.
- Let the best practices be decided by the farmers themselves.
- Extension workers should act as facilitator.
- The research agenda needs to be fulfilled by farmers needs.

Road Map for Development of Citrus Industry

- **Genetic Improvement:**

- Extensive survey, collection, evaluation and morphological and molecular of all classes of citrus from indigenous and exotic sources for desired quality and production.
- Improvement of cultivars through clonal selection, mutation breeding, inter specific hybridization, resistance breeding against phytophthora, nematodes, bacterial and viral diseases.
- Initiation of *in vitro* shoot tip grafting, soma clonal variation and protoplast fusion for production of disease free planting materials.
- Development of virus indexing, rapid diagnostic tools, cross protection stable strain viruses, virus resistant transgenic citrus plants and molecular indexing techniques for multiplication of virus free planting materials.

- **Improved Production Technology**

- Development of Integrated Nutrient Management for standardization of different inorganic fertilizers including FYM, green manure, vermin-compost, neem cake and bio-fertilizers.
- Adoption of high density planting to increase the productivity per unit area.
- Adoption of hi-tech horticulture including micro-propagation, micro irrigation, fertigation, protected cultivation, organic farming, mechanization and use of remote sensing.
- Identification of ideal rootstock–scion combination using local rootstocks for different agroclimatic regions.
- Rejuvenation of old declined orchard through suitable soil conservation measures manuring, dehorning and plant protection measures.
- Development of citrus based farming systems.

- Development of Integrated Pest Management considering thresh hold values population dynamics, forecasting models, chemicals, botanicals, bio-control agents, third generation pesticides and using National Network Project.
- **Post Harvest Management and Value Addition**
 - Creation of basic infrastructure facilities like pre-cooling units, packing and grading shed, short and long term storage facilities, refrigerated containers, storage and phytosanitary facilities at mandi.
 - Development of C.F.B. packages for khasi mandarin.
 - Development of methods for preparation of concentrate or juice powder with natural qualities.
 - Development of viable processes for extraction of colour pigments, flavonoids, essential oils from citrus processing waste.
- **Export Promotion Programme**
 - Identification of potential areas for khasi mandarin in different North-Eastern states for expansion of cultivated area.
 - Initiatives taken by APEDA like NERAMAC as nodal agency to procure and stock the packing materials and preservatives in bulk to cover the requirements of small processing units, introduction of various producers of fresh orange with the exporter in Kolkata for exports from Guwahati to Kolkata, setting up of virtual officer in each state, conducting quality awareness and post harvest training programmes in NE states, putting a separate North Eastern counter in all the international exhibitions, providing financial assistance and airfreight subsidy.
 - As per recommendation in National Conference on “Promotion of Exports from the North Eastern Region” held during 2003, New Delhi, the following Agri – Export zones have been kept under consideration.

Manipur	-	Shitake Mushroom
Arunachal Pradesh	-	Citrus
Nagaland	-	Citrus and Kiwi
Sikkim	-	Large cardamom
Assam	-	Joha rice, ginger and Khasi mandarin

In order to promote export of horticultural products from North Eastern Region, special Inland Transport Subsidy Scheme has been revised as follows:

- Subsidy on transportation by road from NE states upto the India Custom point in the North Eastern Region at the border with adjoining countries.
- Subsidy on transportation by Road from N.E. Region to West Bengal for processing for export.
- Subsidy on the airfreight charges by Airlines from an Airport in the North Eastern states and Bagdogra Airport to Guwahati or Kolkata for exports.

- There is a tremendous scope for growth export market to Bangladesh, China, Bhutan, Thailand, Malaysia and Indonesia from North Eastern Region.
- **Extension Approaches**
 - Establishment of Agricultural Technology Information Centre in different states
 - Condition of on farm trials/FLD on recent technologies developed by concerned organization.
 - Training to farmers/extension functionaries on grafting, pruning, orchard management and citrus based cropping/farming system.
 - Involvement of social scientists for identifying problem, impeding production improvement and planning and execution of the on farm research programmes.
 - Streamlining of proper marketing and pricing policy by Government and Cooperative Societies.

CONCLUSIONS

The North Eastern region has been described as one of major centre of diversity for citrus, banana and mango. This region is the natural home of *Citrus indica*, *C. assamensis*, *C. latipes*, *C. ichagensis*, *C. macroptera*, *C. aurantium*, *C. reticulata*, *C. megaloxycarpa*, *C. jambhiri*, *C. aurantifolia*, *C. grandis*, *C. limon* and *C. karna*. An average temperature of 10-25°C along with cool summer in the region, favours quality fruit production of mandarin oranges for supply from November to February. Foot hills and valleys are ideal for cultivation for sweet oranges, acid limes and Assam lemons. Amongst rootstocks, *Citrus volckamariana*, *Citrus jambhiri*, *Citrus latipes* and *Cleopatra* mandarin have been found as suitable rootstocks for budding/grafting of mandarin oranges. Advancement of genetic make up and adoption of improved production technologies including selection of suitable quality planting materials, soil and nutrient management, training and pruning, high density planting, intercropping, better orchard management practices, IPM and IDM schedules, hi-tech post-harvest processing and value addition, export promotion programme and extension approaches can be effective for rejuvenation of old unproductive citrus orchards

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